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Edge Measurement Validation Program

Introduction

In approaching the question of edge analysis it will be worth reviewing the reasons why this technique has been and is currently of interest.

1) It has been argued for many years on intuitive grounds that a picture consists primarily of edges and that a line drawing made up from the edges alone will transmit most of the information in the picture. Clearly the accuracy with which an edge is recorded is then related to the information content of the picture.

2) Accuracy in measuring the dimension of images in the picture is demonstrably related to the sharpness of the edges.

3) The edge contour is uniquely related to the transfer function of the system. Thus a microdensitometer trace of a suitable photographic edge can be used through knowledge of the film sensitometry to compute the transfer function (or if wanted, the response to a 3-bar target). The problems in doing this with accuracy lie in experimental technique rather than in theory.

4) For operational testing, edge analysis offers the opportunity of using the images of edges in nature (usually man-made) for technical evaluation. In certain situations where targets can be laid out on the ground, edges are physically simple to create and maintain than are large target arrays.

The relationship of microdensitometric edge analysis to other test methods is outlined in Fig. 1. Edge analysis is of interest to us primarily because it offers practical potential (see column 3) of evaluating performance from direct

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examination of operational photography in terms which can be directly related to laboratory test performance and to system design specifications. This use of the edge bears, therefore, on the problem of developing "engineering criteria" for the evaluation of systems.

The method has an advantage where system parameters would dictate impractically large targets spacings on a test range, but more significantly, the method offers an opportunity to evaluate photography of an operational nature. The method is independent of contrast between the regions on each side of the edge and is independent of the brightness provided the exposure lies on the straight line portion of the characteristic curve.

One practical difficulty lies in finding suitable edges in the photography particularly when instrumental conditions require the use of a long slit. In addition it is difficult to determine with certainty whether an edge in a photograph of inaccessible terrain is a truly abrupt transition from one brightness level to another. The edge of a long building may well be affected by shadow or by a terrain change (e.g., narrow walk) next to the building but not resolvable. It would be well to develop rules to guide observers based on viewing and illumination angles in order to minimize such effects.

The theory relating edge trace data to the transfer function is well established. While a variety of computational methods are in use or have been proposed, there does not appear to be any fundamental problem in connection with method with the possible exception of proper and optimum choice of scanning spot or slit. The major problem lies in measurement technique, particularly in obtaining high quality density traces sufficiently free of instrumental noise.

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It is generally agreed in the technical community that at low to moderate resolution good results can probably be obtained with the method although the amount of intercomparison of results between laboratories is limited. At high resolution it is not known what accuracy is possible with available measurements technique or what upgrading of techniques (especially in microdensitometry) will be needed to ensure good results.

Proposed Study

It is clear that it is now both timely and important for the professional community to get answers to some outstanding questions:

What accuracy is possible in obtaining the transfer function from edge trace data?

How repeatable are the results?

To what extent can the techniques be used in a routine way outside the laboratory?

How can one reliably select an edge for measurement in operational photography and be confident it meets the necessary requirements.

Answers to the above questions would no doubt emerge in the course of time as individual laboratories address themselves to the problems. Current problems in photographic evaluation are sufficiently severe, however, that this time scale should be compressed. This is a practical goal since fundamental work is not needed, but rather a tying together and acceleration of current activity. The proposed study is directed toward this end.

It is proposed that a working group including representatives of principal laboratories be established to carry out this work.

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Phase I: Using edges prepared under laboratory conditions (known transfer function) an answer would be obtained to the general question, "What accuracy is possible". The specific results would, of course, include information on accuracy, dependence on density level, density difference, microdensitometer technique, computational method, calibration procedures, etc.

The preparation or procurement of the sample edges would be undertaken by the professional group according to agreed on specifications determined by the group. The sample edges would then be circulated among laboratories, each laboratory making measurements and computations according to the methods of its own choice. There should be an additional circulation of measured curves for intercomparison and to permit the application of computation method B on measurement A, etc. Review of results by the group acting as a committee would provide periodic redirection of emphasis on the activity. The work should be limited to emulsion types of immediate interest, certainly with emphasis on 4404, but with at least one extra faster material for comparison.

PhaseII: Assuming the results of Phase I to be positive, namely that a useful determination of the transfer function be possible, it would then be desirable to consider the problem of working with edges in photographs of random objects. The goal here would be to determine a set of working rules for the selection of edges for measurement which would give consistent results.

General Comments

The work described above is very timely:

1. The transfer function is now generally recognized as the most suitable bridge for connecting theory and practice in evaluating systems. Acceptance of this view is, however, fairly recent since it is only relatively recently that the transfer function has become a recognized engineering tool.

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2. Several laboratories are now actively engaged in edge measurements. Instrumentation and methodology already exists to support the proposed program.

3. The measurements involved are difficult and time consuming. The proposed program should be carried out in a professional way by individuals oriented toward basic science. Industrial members of the group should be informed generally of the purpose of the study and may well be informed on project activity in their company but should not be project team members. They should, in other words, be professionally rather than project oriented.

4. The activity under American Standards Association Subcommittee on Resolving Power Ph 2-16 might well provide a partial model for a way of operation. [redacted] STAT The assignment of the committee is to recommend a standard procedure for testing photographic resolving power that will produce consistent results no matter where it is applied.

The committee is now three years old and results have been slow in coming. This is partly because of the difficulty of the job (it would paradoxically appear almost trivial to a non-expert) and partly perhaps mainly because it is sponsored by each participant as an in-house effort.

5. ~~Our~~ The committee ~~should~~ recommends the initiation of a program along the above lines. It must be recognized that even if initiated immediately the results could not have major impact on the report of the present committee. It might be wise, however, to establish a subcommittee to evolve a detailed work statement for such a study, which work statement could then be part of the final report of the committee.

	STATIC LABORATORY TEST OF INSTRUMENT	DYNAMIC SIMULATION TEST OF INSTRUMENT	OPERATIONAL TEST FOR TECHNICAL PERFORMANCE	OPERATIONAL EVALUATION OF USEFULLNESS OF PHOTOGRAPHY	
3 BAR TARGETS (LOW AND HIGH CONTRAST)	✓	✓	✓ GROUND TARGETS LIMITED AVAILABILITY	LIMITED VALUE SINCE RELATIONSHIP TO P.I. USEFULNESS NOT KNOWN	
SINE WAVE TARGETS	✓	NO ADVANTAGE OVER 3 BAR	GROUND TARGETS PHYSICALLY LARGE (NOT AVAILABLE)		
PHOTOMETRIC EDGE (MICRODENSITOMETRY)	INCONVENIENT THOUGH RELATED TO ABOVE	INCONVENIENT THOUGH RELATED TO ABOVE	✓ PHYSICALLY CONVENIENT	AS ABOVE BUT CONCEPTUALLY MORE RELEVANT	
RES			CONVENIENT BECAUSE OF READING SPEED METHOD NOT VALIDATED		
MIP				✓ SUBJECTIVE JUDGEMENT INCL. SCALE HAZE - NO ACCEPTED STANDARD	
PHOTOGRAPHIC COMPARATORS			✓ COMPARISON WITH PROPERLY DEGRADED IMAGE GIVES A [illegible] BASE	COULD ULTIM[illegible] BE OF USE [illegible] EXERIENCE IS GAINED	FIG. 1

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